FORM PTO-1390 (Modified) (REV 10-95) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: **MAT-7855US**

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR): To Be Assigned 09/445892

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/JP99/02079	19 APR 1999 (19.04.99)	24 APR 1998 (24.04.98)

TITLE OF INVENTION
METHOD FOR MANUFACTURING A MULTI-LAYERED CERAMIC SUBSTRATE

APPLICANT(S) FOR DO/EO/US
Shigetoshi Segawa; Hiroshi Ochi; Yasuyuki Baba; Osamu Shiraishi; Masao Konishi

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 18 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
    A **SECOND** or **SUBSEQUENT** preliminary amendment.
16. ☐ A substitute specification.
17. ☐ A change of power of attorney and/or address letter.
18. ☒ Certificate of Mailing by Express Mail
19. ☐ Other items or information:

420 Rec'd PCT/PTO 14 DEC 1999

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/445892 To Be Assigned	PCT/JP99/02079	MAT-7855US

20. The following fees are submitted:.

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

		CALCULATIONS PTO USE ONLY
☒ Search Report has been prepared by the EPO or JPO	$840.00	
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482)	$670.00	
☐ No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2))	$760.00	
☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2) paid to USPTO	$970.00	
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4)	$96.00	

ENTER APPROPRIATE BASIC FEE AMOUNT =	$840.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).	$0.00	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	13 - 20 =	0	x $18.00	$0.00	
Independent claims	2 - 3 =	0	x $78.00	$0.00	
Multiple Dependent Claims **(check if applicable)**.			☐	$0.00	
TOTAL OF ABOVE CALCULATIONS =				$840.00	
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) **(check if applicable).**			☐	$0.00	
SUBTOTAL =				$840.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +				$0.00	
TOTAL NATIONAL FEE =				$840.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).**			☐	$0.00	
TOTAL FEES ENCLOSED =				$840.00	
				Amount to be: refunded	$
				charged	$

☒ A check in the amount of $ 840 00 to cover the above fees is enclosed.

☐ Please charge my Deposit Account No. in the amount of to cover the above fees.
A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **18-0350** A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Lawrence E. Ashery
Ratner & Prestia
P.O. Box 980
Valley Forge, PA 19482
(610) 407-0700

SIGNATURE

Lawrence E. Ashery
NAME

34,515
REGISTRATION NUMBER

14 December 1999
DATE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	Shigetoshi Segawa et al.	: Art Unit: To Be Assigned
Serial No.:	To Be Assigned	: Examiner: To Be Assigned
Filed:	Herewith	:
FOR:	METHOD FOR MANUFACTURING A MULTI-LAYERED CERAMIC SUBSTRATE	:

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

S I R :

Prior to examination, please amend the above application as follows:

IN THE SPECIFICATION:

After the title and before the first paragraph, please insert --THIS APPLICATION IS A U.S. NATIONAL PHASE APPLICATION OF PCT INTERNATIONAL APPLICATION PCT/JP99/02079--.

Please enter the substitute specification as attached hereto. Also enclosed is marked-up copy of the substitute specification showing additions and deletions.

IN THE DRAWINGS:

Please delete page "3/3" of the drawings, also labeled as "Reference Numerals" in its entirety.

IN THE CLAIMS:

Please amend the claims as follows:

1. (Once Amended) A method for manufacturing a multi-layered ceramic substrate, said method comprising the steps of:

forming a shrinkage suppression sheet on at least one face [both faces] of an unfired green sheet laminated body;

firing said green sheet laminated body on which said shrinkage suppression sheet is formed on the [its both] at least one face [faces]; and

removing said shrinkage suppression sheet by spraying at least one of ceramic powder and water together with compressed air onto said shrinkage suppression sheet on [both] the at least one face [faces] of said green sheet laminated body after firing.

2. (Once Amended) The method for manufacturing a multi-layered ceramic substrate as defined in Claim 1, wherein said ceramic powder is made [of the same] from a material, said material being the same as [the main constituent of] a material used [for] in said shrinkage suppression sheet.

3. (Once Amended) The method for manufacturing a multi-layered ceramic substrate as defined in Claim 1, wherein the shrinkage suppression sheet has a sintering temperature [of said shrinkage suppression sheet] which is higher than a [the] sintering temperature of said green sheet laminated body.

4. (Once Amended) The method for manufacturing a multi-layered ceramic substrate as defined in Claim 1, wherein [the pressure of] said compressed air has a pressure [is] between 3.0 and 5.5 kgf/cm^2.

7. (Once Amended) The method for manufacturing a multi-layered ceramic substrate as defined in Claim 1, wherein said shrinkage

suppression sheet is formed on both faces of said unfired green sheet laminated body and at least one of said ceramic powder and water is sprayed together with compressed air onto said shrinkage suppression sheet on both faces of said green sheet laminated body simultaneously after firing.

8. (Once Amended) The method for manufacturing a multi-layered ceramic substrate as defined in Claim 1, wherein said [sprayed] ceramic powder is collected, after spraying, for reuse [in spraying].

9. (Once Amended) A method for manufacturing a multi-layered ceramic substrate, said method comprising the steps of:

forming a [in which a] shrinkage suppression sheet [is formed] on [both] two faces of an unfired [laminated] green [sheets] sheet laminated body;

[before] firing said green sheet laminated body; and

[, and said] removing said shrinkage suppression [sheets] sheet [is removed after sintering; wherein said shrinkage suppression sheet is removed] by spraying at least one of water, ceramic powder, and a mixture of ceramic powder and water together with compressed air onto at least one of the two faces of said green sheet laminated body, after firing.

10. (Once Amended) The method for manufacturing a multi-layered ceramic substrate as defined in Claim 9, wherein the [pressure of said] compressed air has a pressure [is] between 3.0 and 5.5 kgf/cm^2.

13. (Once Amended) The method for manufacturing a multi-layered ceramic substrate as defined in Claim 9, wherein said ceramic powder is made of a material, said material being the same as a material used in said shrinkage suppression sheet [The method for manufacturing a multi-layered ceramic substrate as defined in Claim 9, wherein said ceramic powder mixed with said compressed air and water is made of the same material as the main constituent of a material used for said shrinkage suppression sheet].

Respectfully submitted,

Lawrence E. Ashery, Reg. No. 34,515
Attorney for Applicants

LEA/lm
Dated: December 14, 1999
Suite 301, One Westlakes, Berwyn
P.O. Box 980
Valley Forge, PA 19482-0980
(610) 407-0700
EXPRESS MAIL Mailing Label Number:EL399196533US
Date of Deposit: December 14, 1999

I hereby certify that this paper and fee are being deposited, under 37 C.F.R. § 1.10 and with sufficient postage, using the "Express Mail Post Office to Addressee" service of the United States Postal Service on the date indicated above and that the deposit is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

Kathleen Libby

Kathleen Libby

METHOD FOR MANUFACTURING A MULTI-LAYERED CERAMIC SUBSTRATE

FIELD OF THE INVENTION

The present invention relates to the field of methods for manufacturing a multi-layered ceramic substrate used for electronic devices, and in particular to methods for manufacturing a non-shrinkable multi-layered substrate which greatly suppresses shrinkage of the substrate during firing.

BACKGROUND OF THE INVENTION

Normally, multi-layered ceramic substrates are manufactured using a method called the green sheet lamination method. In this method, green sheets, made by forming a slurry containing ceramic powder and organic binder into a sheet, are punched (for holes) and screen printed with conductive paste. These green sheets are stacked to the required number, press-heated to laminate the layers, and then fired.

The advantages of this method include the feasibility of fine pattern printing realized by the extremely flexible green sheet and good permeability to organic solvents, and good surface smoothness and air-tightness which allow the lamination of even up to several dozens of layers.

On the other hand, the main disadvantage is the difficulty in achieving dimensional accuracy. This is due to shrinkage of the ceramic substrate accompanied by sintering which occurs during firing. Inaccurate dimensions cause mismatching between components and conductive patterns, generating the serious problem of inability to mount semiconductor chips such as CSPs (chip size packages) and MCMs (multi-chip modules) with high accuracy.

As a result, recent developments have been focusing on a method for eliminating lateral shrinkage during firing. This method involves the formation of shrinkage suppression sheets, using the doctor blade method, containing a ceramic material such as alumina which does not sinter at the sintering temperature of green sheet. These sheets are disposed on both faces of the green sheet laminated body and fired. The sintered multi-layered ceramic substrate then shrinks only in the thickness direction and not in the lateral direction, enabling semiconductor chips to be mounted with much higher accuracy.

Fig. 2 shows the conventional method for manufacturing a multi-layered ceramic substrate 2. After firing the multi-layered ceramic substrate 2, shrinkage suppression sheets 1 on both faces of a multi-layered ceramic substrate are removed by rotating a dry rotary brush 3 at high speed, as illustrated in Fig. 2.

However, this conventional removal method may not be able to accurately control the amount of the shrinkage suppression sheet to be removed by simply changing the rotation speed of the rotary brush or the distance to the substrate, i.e., the strength of the brush polishing the substrate. For example, too slow brush rotation speed or insufficient polishing time causes uneven removal. The conductive pattern on the surface of the multi-layered substrate may be damaged if the revolution of the brush is too fast or polishing time is too long. As a result, the conductive pattern may be disconnected or short-circuited, resulting in a low yield rate. Furthermore, in the case of an irregularly-shaped substrate with a cavity A on the surface of the multi-layered substrate, as shown in Fig. 2, residue in the cavity A is not always successfully removed by the rotary brush 3.

SUMMARY OF THE INVENTION

A method for manufacturing a multi-layered ceramic substrate of the present invention involves spraying of water, ceramic powder, or a mixture of ceramic powder and water together with compressed air for removing a shrinkage suppression sheet from a green sheet laminated body containing low-temperature firing substrate material.

The fine controllability of this method, by changing the pressure of compressed air, enables the removal of the shrinkage suppression sheet completely without causing uneven removal even if a cavity exists in the substrate. In addition, the polishing capability improves by adding ceramic powder.

Furthermore, properties of the ceramic powder used to create the green sheet laminated body remain unchanged, even if the removed shrinkage suppression sheet material mixes with the ceramic powder, because the same material is used for the ceramic powder which is sprayed and as the main constituent of the shrinkage suppression sheet. Accordingly, sprayed ceramic powder can be collected for reuse in spraying, enabling this method to be applied to circulating continuous devices.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view depicting a method for manufacturing a multi-layered ceramic substrate in accordance with an exemplary embodiment of the present invention.

Fig. 2 is a side view depicting a method for manufacturing a multi-layered ceramic substrate of the prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A first exemplary embodiment of the present invention is described with reference to Fig. 1. A green sheet laminated body 2 is an unfired multi-

layered low-temperature firing substrate, before sintering, made typically of alumina and glass. Shrinkage suppression sheets 1 formed by the doctor blade method, are disposed on both faces of the green sheet laminated body 2. A material which does not sinter at the sintering temperature of the green sheet laminated body 2 is selected for the shrinkage suppression sheet 1. Typically, the shrinkage suppression sheet 1 is made of a ceramic material such as alumina. Then, the green sheet laminated body 2, on which the shrinkage suppression sheets 1 are formed on both faces, is fired.

After firing, the shrinkage suppression sheets 1 formed on both faces of the green sheet laminated body 2 are removed by spraying a mixture of water and alumina powder from a nozzle 4 connected to a feeding pipe for supplying water and alumina powder mixture 5 and a feeding pipe for supplying compressed air 6. The shrinkage suppression sheets 1 are thus removed by the injection pressure of water and alumina powder mixture.

Conditions for removing the shrinkage suppression sheet were studied, and two examples are described below. In the examples, a multi-layered ceramic substrate 2 of 115 mm x 115 mm and a 200 μm thick shrinkage suppression sheet 1 made of alumina are used.

Table 1 shows the process conditions and the satisfactory results obtained by mixing 96 g of water and 4 g of alumina powder with a mean particle size of 0 to 10 μm, and spraying the mixture for about 100 to 400 seconds using compressed air at a pressure of 3.0 to 5.5 kg/cm^2.

In a second exemplary embodiment, Table 2 shows process conditions and the satisfactory results obtained by using only alumina powder with a mean particle size of 0.1 to 150 μm without using water, and spraying alumina

powder for about 100 to 400 seconds using compressed air at a pressure of 3.0 to 5.5 kg/cm^2.

In these embodiments, the distance between the multi-layered ceramic substrate 2 and nozzle 4 was about 50 mm. After removal, the substrate was rinsed with deionized water at 120 ± 5 °C for 15 minutes. Table 1also shows a comparison of the results of the conventional manufacturing method and that of the present invention.

Table 1

	First Exemplary Embodiment (using water)						prior art
Pressure (Kg/cm^2)	5.3	3.5	3.5	3.5	3.5	3.5	brush
use of water	yes	yes	Yes	yes	yes	yes	no
Particle size(μm)	0	0.5	1.0	2.5	5.0	10	-
Removal time (sec)	400	300	200	150	100	100	500
Uneven removal	no	no	No	no	no	no	yes
Damage to substrate	no	no	No	no	no	no	scratches by brush
Irregularly-shaped substrate	easy	easy	Easy	easy	easy	easy	difficult

Table 2

	Secondary Exemplary Embodiment (without using water)				
Pressure (Kg/cm^2)	3.5	3.5	3.5	3.5	2.5
use of water	no	no	no	No	no
Particle size(μm)	0.1	10	50	100	150
Removal time (sec)	400	250	200	100	100
Uneven removal	no	no	no	No	no
Damage to substrate	no	no	no	No	no
Irregularly-shaped substrate	easy	easy	easy	Easy	easy

In a third exemplary embodiment of the present invention, the shrinkage suppression sheet may be removable by spraying just water without ceramic powder, combined with compressed air.

In the exemplary embodiments of the present invention it is preferable that the mean particle size of ceramic powder for removing the shrinkage suppression sheet 1 not exceed the range as shown in Tables 1 and 2, as cracks may occur on the surface of the ceramic substrate. Also, in the preferred embodiment the present invention it is preferred that the pressure of the compressed air not exceed the range as shown in Tables 1 and 2, it may take too much time for removing the shrinkage suppression sheet 1, or cause cracks on the substrate surface or breakage of the substrate.

In these exemplary embodiments, the green sheet laminated body 2 contains alumina, and the shrinkage suppression sheet 1 contains alumina powder. Accordingly, one advantage of the exemplary embodiments is that, after printing conductive resistance material and the like in the process after removing the shrinkage suppression sheet 1 impurities consisting of organic substances do not react with the printed materials and cause a detrimental effects on the laminated body when firing the green sheet laminated body 2. This is due to the use of inorganic alumina powder as a material for forming the shrinkage suppression sheet, which is the same material used in the ceramic powder used to form the green sheet laminated body 2. The conventional method removes the shrinkage suppression sheet 1 by means of a rapidly rotating brush. Therefore burning may occur on the surface of the green sheet laminated body 2 by organic substance in the brush, depending on the material of the brush. The remaining organic

substance may cause detrimental effects to the laminated body when firing the green sheet laminated body 2 after removing the shrinkage suppression sheet 1.

Another advantage of the present invention enables the prevention of uneven removal or damage to the conductive pattern which occurs in the conventional method, and the reduction of operation time. Even for irregularly-shaped multi-layered substrate with cavities on its surface, the shrinkage suppression sheet may be removed completely. Polishing strength is finely controllable by adjusting the mixing ratio of spraying liquid, air pressure, time, and nozzle distance. In addition, the operation can be executed on both faces simultaneously by clamping the substrate.

Accordingly, shrinkage of the substrate during firing is suppressed to an extremely high degree, and a non-shrinkable multi-layered substrate can be reliably manufactured. This enables the mounting of components on multi-layered substrates without any mismatching between components and their respective conductive patterns, and also the mounting of semiconductor chips such as CSPs (chip size packages) and MCMs (multi-chip modules) with high accuracy, making high density mounting feasible.

Furthermore, the use of the same material for the ceramic powder to be sprayed, and as the main constituent of shrinkage suppression sheet, allows the collecting of sprayed ceramic powder for reuse in spraying, enabling this method to be applied to circulating continuous devices.

METHOD FOR MANUFACTURING A MULTI-LAYERED CERAMIC SUBSTRATE

FIELD OF THE INVENTION

The present invention relates to the field of methods for manufacturing a multi-layered ceramic substrate used for electronic devices, and in particular to methods for manufacturing a so-called non-shrinkable multi-layered substrate which greatly suppresses shrinkage of the substrate during firing.

BACKGROUND OF THE INVENTION

Normally, multi-layered ceramic substrates are manufactured using a method called the green sheet lamination method. In this method, green sheets, made by forming a slurry containing ceramic powder and organic binder into a sheet, are punched (for holes) and screen printed with conductive paste. These green sheets are stacked to the required number, press-heated to laminate the layers, and then fired.

The advantages of this method include the feasibility of fine pattern printing realized by the extremely flexible green sheet and good permeability to organic solvents; and good surface smoothness and air-tightness which allow the lamination of even up to several dozens of layers.

On the other hand, the main disadvantage is the difficulty in achieving dimensional accuracy. This is due to shrinkage of the ceramic substrate accompanied by sintering which occurs during firing it. Inaccurate dimensions cause mismatching between components and conductive patterns, generating the serious problem of inability to mount semiconductor chips such as CSPs (chip size packages) and MCMs (multi-chip modules) with high accuracy.

As a result, recent developments have been focusing on a method for eliminating lateral shrinkage during firing. This method involves the formation of shrinkage suppression sheets, using the doctor blade method, containing a ceramic material such as alumina which does not sinter at the sintering temperature of green sheet. These sheets are disposed on both faces of the green sheet laminated body and fired. The sintered multi-layered ceramic substrate then shrinks only in the thickness direction and not in the lateral direction, enabling semiconductor chips to be mounted with much higher accuracy.

Fig. 2 shows the conventional method for manufacturing a multi-layered ceramic substrate 2. After firing the multi-layered ceramic substrate 2, shrinkage suppression sheets 1 on both faces of a multi-layered ceramic substrate are removed by rotating a dry rotary brush 3 at high speed, as illustrated in Fig. 2.

However, this conventional removal method may not be able to accurately control amount of shrinkage suppression sheet to be removed by simply changing the rotation speed of the rotary brush or the distance to the substrate, i.e., the strength of the brush polishing the substrate. For example, too slow brush rotation speed or insufficient polishing time causes uneven removal. The conductive pattern on the surface of the multi-layered substrate may be damaged if the revolution of the brush is too fast or polishing time is too long. As a result, the conductive pattern may be disconnected or short-circuited, resulting in a low yield rate. Furthermore, in the case of an irregularly-shaped substrate with a cavity A on the surface of the multi-layered substrate, as shown in Fig. 2, residue in the cavity A is not always successfully removed by the rotary brush 3.

SUMMARY OF THE INVENTION

A method for manufacturing a multi-layered ceramic substrate of the present invention involves spraying of water, ceramic powder, or a mixture of ceramic powder and water together with compressed air for removing a shrinkage suppression sheet from a green sheet laminated body contained low-temperature firing substrate material.

The fine controllability of this method by changing the pressure of compressed air enables to remove the shrinkage suppression sheet completely without causing uneven removal even if a cavity exists in the substrate. In addition, its polishing capability improves by adding ceramic powder.

Furthermore, conditions of ceramic powder remain unchanged even removed shrinkage suppression sheet material mixes with ceramic powder because the same material is used for ceramic powder to be sprayed and main constituent of the shrinkage suppression sheet. Accordingly, sprayed ceramic powder can be collected for reuse in spraying, enabling this method to be applied to circulating continuous devices.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view depicting a method for manufacturing a multi-layered ceramic substrate in accordance with an exemplary embodiment of the present invention.

Fig. 2 is a side view depicting a method for manufacturing a multi-layered ceramic substrate of the prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENT

An exemplary embodiment of the present invention is described with reference to Fig. 1. A green sheet laminated body 2 is an unfired multi-layered

low-temperature firing substrate, before sintering, made typically of alumina and glass. Shrinkage suppression sheets 1 formed by the doctor blade method are disposed on both faces of the green sheet laminated body 2. A material which does not sinter at the sintering temperature of the green sheet laminated body 2 is selected for the shrinkage suppression sheet 1. Typically, the shrinkage suppression sheet 1 is made of a ceramic material such as alumina. Then, the green sheet laminated body 2, on which the shrinkage suppression sheets 1 are formed on both faces, is fired.

After firing, the shrinkage suppression sheets 1 formed on both faces of the green sheet laminated body 2 are removed by spraying a mixture of water and alumina powder from a nozzle 4 connected to a feeding pipe for supplying water and alumina powder mixture 5 and a feeding pipe for supplying compressed air 6. The shrinkage suppression sheets 1 are thus removed by the injection pressure of water and alumina powder mixture.

Conditions for removing the shrinkage suppression sheet were studied, and two examples are described below. In the examples, a multi-layered ceramic substrate 2 of 115 mm x 115 mm and a 200 μm thick shrinkage suppression sheet 1 made of alumina are used.

(EXAMPLE 1)

Table 1 shows the process conditions and the satisfactory results obtained by mixing 96 g of water and 4 g of alumina powder with a mean particle size of 0 to 10 μm, and spraying the mixture for about 100 to 400 seconds using compressed air at a pressure of 3.0 to 5.5 kg/cm^2.

(EXAMPLE 2)

Table 2 shows process conditions and the satisfactory results obtained by using only alumina powder with a mean particle size of 0.1 to 150 μm without

using water, and spraying alumina powder for about 100 to 400 seconds using compressed air at a pressure of 3.0 to 5.5 kg/cm^2.

In these examples, the distance between the multi-layered ceramic substrate 2 and nozzle 4 was about 50 mm. After removal, the substrate was rinsed with deionized water at 120 ± 5 °C for 15 minutes. Tables 1 and 2 also show a comparison of the results of the conventional manufacturing method and that of the present invention.

Table 1

	EXAMPLE 1 (using water)						prior art
pressure (Kg/cm^2)	5.3	3.5	3.5	3.5	3.5	3.5	brush
use of water	yes	yes	yes	yes	yes	yes	no
particle size(μm)	0	0.5	1.0	2.5	5.0	10	-
removal time (sec)	400	300	200	150	100	100	500
uneven removal	no	no	no	no	no	no	yes
Damage to substrate	no	no	no	no	no	no	scratches by brush
irregularly-shaped substrate	easy	easy	easy	easy	easy	easy	difficult

Table 2

	EXAMPLE 2 (without using water)				
pressure (Kg/cm^2)	3.5	3.5	3.5	3.5	2.5
use of water	no	no	no	no	no
particle size(μm)	0.1	10	50	100	150
removal time (sec)	400	250	200	100	100
uneven removal	no	no	no	no	no
Damage to substrate	no	no	no	no	no
irregularly-shaped substrate	easy	easy	easy	easy	easy

In this exemplary embodiment, the green sheet laminated body 2 contains alumina, and the shrinkage suppression sheet 1 contains alumina powder.

Accordingly, impurities do not react with the conductive paste and cause a detrimental effects on the laminated body when firing the green sheet laminated body 2 after printing resistance and the like in the process after removing the shrinkage suppression sheet 1. This is due to the use of inorganic alumina powder, which is of the same constituent as the shrinkage suppression sheet, for ceramic powder. Since the conventional method removes the shrinkage suppression sheet 1 by means of a rapidly rotating brush, burning may occur on the surface of the green sheet laminated body 2 by organic substance in the brush, depending on the material of the brush. The remaining organic substance may cause detrimental effects to the laminated body when firing the green sheet laminated body 2 after removing the shrinkage suppression sheet 1.

If the mean particle size of ceramic powder for removing the shrinkage suppression sheet 1 exceeds the range shown in the above examples, cracks may occur on the surface of the ceramic substrate. If the pressure of the compressed air exceeds the above range, it may take too much time for removing the shrinkage suppression sheet 1, or cause cracks on the substrate surface or breakage of the substrate.

The shrinkage suppression sheet is also removable by spraying just water without ceramic powder, combined with compressed air.

Industrial applicability

In the manufacture of a multi-layered ceramic substrate by forming shrinkage suppression sheets on both faces of unfired laminated green sheets, firing the laminated green sheets, and removing the shrinkage suppression sheets; the present invention enables to prevent uneven removal or damage to the conductive pattern which occurs in the conventional method, and reduce operation time. Even

for irregularly-shaped multi-layered substrate with cavities on its surface, the shrinkage suppression sheet may be removed completely. Polishing strength is finely controllable by adjusting the mixing ratio of spraying liquid, air pressure, time, and nozzle distance. In addition, the operation can be executed on both faces simultaneously by clamping the substrate.

Accordingly, shrinkage of the substrate during firing is suppressed to an extremely high degree, and so-called non-shrinkable multi-layered substrate can be reliably manufactured. This enables to mount components on multi-layered substrates without any mismatching between components and their respective conductive patterns, and also mount semiconductor chips such as CSPs (chip size packages) and MCMs (multi-chip modules) with high accuracy, making high density mounting feasible.

Furthermore, the use of same material for ceramic powder to be sprayed and main constituent of shrinkage suppression sheet allows to collect sprayed ceramic powder for reuse in spraying, enabling this method to be applied to circulating continuous devices.

What is claimed is:

1. A method for manufacturing a multi-layered ceramic substrate, said method comprising the steps of:

forming a shrinkage suppression sheet on both faces of an unfired green sheet laminated body;

firing said green sheet laminated body on which said shrinkage suppression sheet is formed on its both faces; and

removing said shrinkage suppression sheet by spraying at least one of ceramic powder and water together with compressed air onto said shrinkage suppression sheet on both faces of said green sheet laminated body after firing.

2. The method for manufacturing a multi-layered ceramic substrate as defined in Claim 1, wherein said ceramic powder is made of the same material as the main constituent of a material used for said shrinkage suppression sheet.

3. The method for manufacturing a multi-layered ceramic substrate as defined in Claim 1, wherein the sintering temperature of said shrinkage suppression sheet is higher than the sintering temperature of said green sheet laminated body.

4. The method for manufacturing a multi-layered ceramic substrate as defined in Claim 1, wherein the pressure of said compressed air is between 3.0 and 5.5 kgf/cm^2.

5. The method for manufacturing a multi-layered ceramic substrate as defined in Claim 1, wherein a mean particle size of said ceramic powder is not greater than 10 μm.

6. The method for manufacturing a multi-layered ceramic substrate as defined in Claim 1, wherein a mean particle size of said ceramic powder is between 0.1 and 150 μm.

7. The method for manufacturing a multi-layered ceramic substrate as defined in Claim 1, wherein at least one of said ceramic powder and water is sprayed together with compressed air onto said shrinkage suppression sheet on both faces of said green sheet laminated body simultaneously after firing.

8. The method for manufacturing a multi-layered ceramic substrate as defined in Claim 1, wherein said sprayed ceramic powder is collected for reuse in spraying.

9. A method for manufacturing a multi-layered ceramic substrate in which a shrinkage suppression sheet is formed on both faces of unfired laminated green sheets before firing, and said shrinkage suppression sheet is removed after sintering; wherein said shrinkage suppression sheet is removed by spraying at least one of water, ceramic powder, and a mixture of ceramic powder and water together with compressed air.

10. The method for manufacturing a multi-layered ceramic substrate as defined in Claim 9, wherein the pressure of said compressed air is between 3.0 and 5.5 kgf/cm^2.

11. The method for manufacturing a multi-layered ceramic substrate as defined in Claim 9, wherein a mean particle size of said ceramic powder is not greater than 10 μm.

12. The method for manufacturing a multi-layered ceramic substrate as defined in Claim 9, wherein a mean particle size of said ceramic powder is between 0.1 and 150 μm.

13. The method for manufacturing a multi-layered ceramic substrate as defined in Claim 9, wherein said ceramic powder mixed with said compressed air and water is made of the same material as the main constituent of a material used for said shrinkage suppression sheet.

ABSTRACT OF THE DISCLOSURE

A method for manufacturing a multi-layered ceramic substrate which enables to remove a shrinkage suppression sheet without damaging the multi-layered substrate. The shrinkage suppression sheets are formed on both faces of unfired laminated green sheets, and then the laminated green sheets are fired. For removing the shrinkage suppression sheets on both faces of the multi-layered ceramic substrate 2 after sintering, water, ceramic powder, or water and ceramic powder mixture is sprayed together with compressed air.

Reference numerals

1	shrinkage suppression sheet
2	green sheet laminated body
3	rotary brush
4	nozzle
5	feeding pipe for supplying water and alumina powder mixture
6	feeding pipe for supplying compressed air

FIG. 1

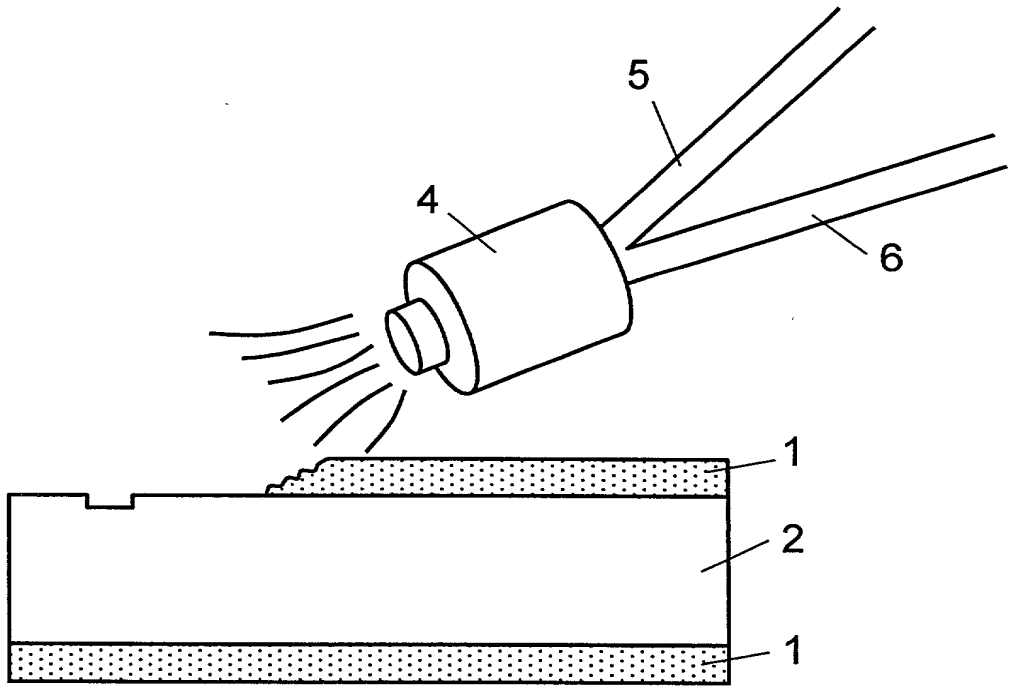
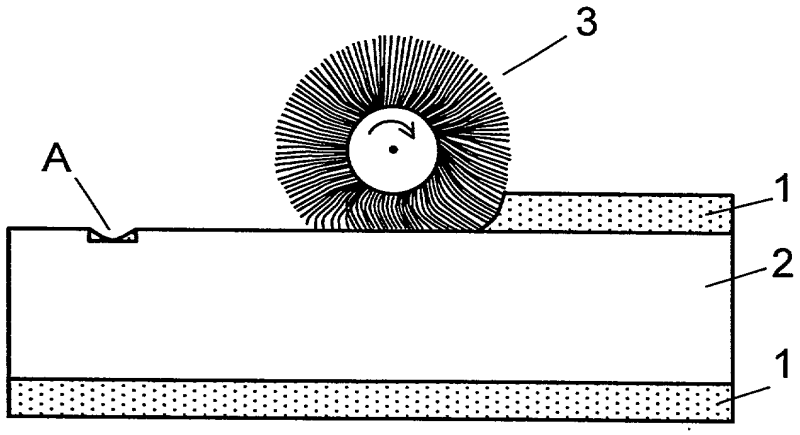


FIG. 2 PRIOR ART



Declaration and Power of Attorney For Patent Application
English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled
METHOD FOR MANUFACTURING A MULTI-LAYERED CERAMIC SUBSTRATE,
the specification of which is attached hereto unless the following box is checked:

☒ was filed on April 19, 1999 as
United States Application Number or PCT International Application Number PCT/JP99/02079
and was amended on December 14, 1999 (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. §119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below by checking the box, any foreign application for patent or inventor's certificate, or PCT international application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Not Claimed
10-114671	Japan	24 April 1998	
(Number)	(Country)	(Day/Month/Year Filed)	☐
(Number)	(Country)	(Day/Month/Year Filed)	☐

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below.

—	—
(Application Number)	(Filing Date)
—	—
(Application Number)	(Filing Date)

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Number)	(Filing Date)	(Status - patented, pending, abandoned)
(Application Number)	(Filing Date)	(Status - patented, pending, abandoned)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

Paul F. Prestia	Reg. No. 23,031	Lawrence E. Ashery	Reg. No. 34,515	Mark J. Marcelli	Reg. No. 36,593
Allan Ratner	Reg. No. 19,717	Christopher R. Lewis	Reg. No. 36,201	Joshua L. Cohen	Reg. No. 38,040
Andrew L. Ney	Reg. No. 20,300	Robert L. Andersen	Reg. No. 25,771	Jack J. Jankovitz	Reg. No. 42,690
Kenneth N. Nigon	Reg. No. 31,549	Daniel N. Calder	Reg. No. 27,424		
Kevin R. Casey	Reg. No. 32,117	Louis W. Beardell, Jr.	Reg. No. 40,506		
Benjamin E. Leace	Reg. No. 33,412	Jacques L. Etkowicz,	Reg. No. 41,738		
James C. Simmons	Reg. No. 24,842	Eric A. Dichter	Reg. No. 41,708		

Address all correspondence to: Lawrence E. Ashery
Ratner & Prestia, Suite 301, One Westlakes, Berwyn, P.O. Box 980, Valley Forge, PA 19482-0980
Address all telephone calls to: Lawrence E. Ashery at (610) 407-0700.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor (given name, family name) **Shigetoshi Segawa**

Inventor's signature Shigetoshi SEGAWA Date March 31, 2000
Residence Ehime, Japan JPX
Citizenship Japanese
Post Office Address 2496-5, Hagyu, Niihama-shi, Ehime 792-0050, Japan

Full name of second joint inventor, if any (given name, family name) **Hiroshi Ochi**

Second Inventor's signature Hiroshi Ochi Date March 31, 2000
Residence Ehime, Japan JPX
Citizenship Japanese
Post Office Address 454-15, Hinokuchi, Saijo-shi, Ehime 793-0043, Japan

☒ Additional inventors are being named on separately numbered sheets attached hereto.

300 Full name of third joint inventor, if any (given name, family name) **Yasuyuki Baba**

Third inventor's signature Yasuyuki Baba Date March 31, 2000

Residence Ehime, Japan JPX

Citizenship Japanese

Post Office Address 1-140, Tenjin, Saijo-shi, Ehime 793-0002, Japan

400 Full name of fourth joint inventor, if any (given name, family name) **Osamu Shiraishi**

Fourth inventor's signature Osamu Shiraishi Date March 31, 2000

Residence Ehime, Japan JPX

Citizenship Japanese

Post Office Address 267-2, Omachi, Saijo-shi, Ehime 793-0030, Japan

500 Full name of fifth joint inventor, if any (given name, family name) **Masao Konishi**

Fifth inventor's signature Masao Konishi Date March 31, 2000

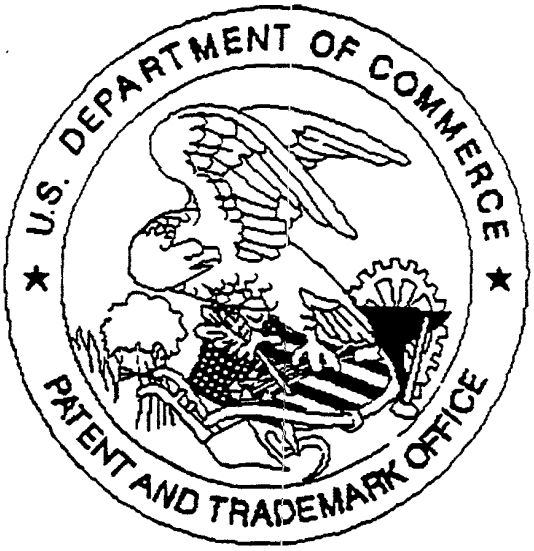
Residence Ehime, Japan JPX

Citizenship Japanese

Post Office Address 2780-12, Hagyu, Niihama-shi, Ehime 792-0050, Japan

United States Patent & Trademark Office

Office of Initial Patent Examination -- Scanning Division



Application deficiencies were found during scanning:

☐ Page(s)_____ of _____ were not present for scanning.
(Document title)

☐ Page(s)_____ of _____ were not present for scanning.
(Document title)

There are only 2 sheets of drawings.

☐ Scanned copy is best available.